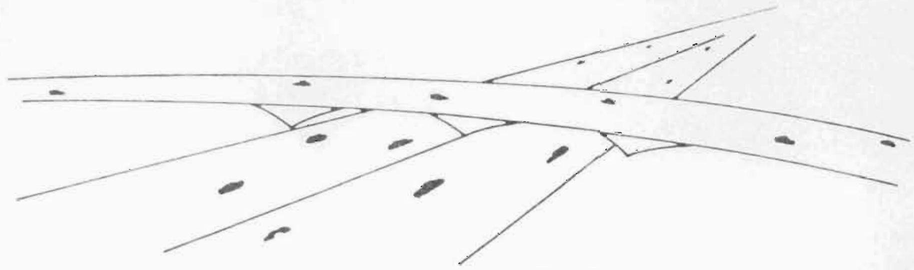


DEPARTMENTAL RESEARCH

Report Number SS15.12

INVESTIGATION OF DETERIORATED HOT MIX ASPHALTIC CONCRETE RESULTING IN A MODIFIED SOUNDNESS TEST FOR AGGREGATES

MATERIALS & TESTS
LIBRARY
TEXAS HIGHWAY DEPARTMENT

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

INVESTIGATION OF DETERIORATED HOT MIX ASPHALTIC CONCRETE RESULTING IN A MODIFIED SOUNDNESS TEST FOR AGGREGATES

by

Vernon D. McCall
Supervising Laboratory Engineer

SS 15.12

District 6
State Department Of Highways And Public Transportation

June 1975

ABSTRACT

Investigation of early deterioration of hot mix asphaltic concrete showed that poor quality aggregate was the main cause. The majority of the aggregates used were of inferior quality and were not detected by the Wet Ball Mill test or the Los Angeles Abrasion test.

A modified Soundness of Aggregate test (Tex-411-A) was found to confirm the high absorbency and low durability of the aggregates which contributed to road surface failure.

Since using the modified test to identify and eliminate the use of inferior aggregates, none of the eight projects checked since 1971 shows indication of deterioration or surface cracking.

SUMMARY

Hot mix asphaltic concrete on I-10 in Pecos and Reeves counties failed by cracking and surface disintegration soon after application. Investigation showed that poor quality aggregate was the main cause of failure. Fifteen additional Hot Mix Asphaltic concrete Projects throughout District 6 were investigated. The majority of the aggregates were of inferior quality and were not detected by the two tests outlined in this report.

The Los Angeles test (Tex-410-A) and the Wet Ball Mill test (Tex-116-E) failed to pinpoint poor quality material. The fourth cycle of a modified Soundness of Aggregates test confirmed the high absorbency and low durability of aggregates which caused the road surface disintegration.

A modified Test Method Tex-441-A (ASTM C 88) Soundness of Aggregate by Use of Magnesium Sulfate, which included a 25 percent maximum value of unsound material after four cycles, has been used to determine aggregate quality since 1971.

After inauguration of this test to eliminate poor quality aggregate not one of the eight road projects using Type "C" or "D" HMAC has shown any indication of failure.

Since requiring the modified specification it has been observed that 1-1/2 to 2 percent less asphalt was needed in mixes because of a decrease in the use of absorptive aggregates.

I. SUBJECT

Deteriorated hot mix asphaltic concrete on I-10 was investigated and cracking and disintegration of the road surface was found to have occurred before the end of the first winter of application.

Experience on the sixteen projects throughout District 6 was reviewed and early deterioration and cracking had been noted except when gravel or durable sound aggregate was used. This observation led to the study of aggregate quality outlined in this report.

During the design procedure of some hot mix asphaltic concrete, some aggregates showed a very high absorption rate. These aggregates required near maximum asphalt contents which had to be reduced during project construction to meet density requirements caused by degradation of the aggregate during molding. On projects where the highly absorptive less durable aggregates were used, deterioration and cracking of the surface occurred within periods ranging from less than a year to thirty months after placement. On projects using aggregates with lower absorption rates, the pavement surface showed less deterioration and better servicability.

II. PURPOSE

The purpose of this investigation was to determine the cause of failure of HMAC on various projects throughout the District and to find a solution to the problem.

III. CONCLUSIONS

It was found that the use of low quality aggregate resulted in cracking and surface disintegration of the roadway. The Los Angeles test and the Wet

Ball Mill test failed to pinpoint the high absorbency and low durability of the aggregate. The fourth cycle of a modified Test Method Tex-411-A (Soundness of Aggregate) indentified the inferior material, and paralleled both the length of time and the magnitude of the failure on each project for each pit. Experience in the use of this test since 1971 has revealed no similar failures on the eight projects checked and a general saving of from 1-1/2 to 2 percent in asphalt use on these projects.

IV. MATERIALS

Core samples were taken from HMAC road surface of I-10. Hot mix Type "C" and "D" aggregates from sixteen local pits were tested (see Appendix).

V. TEST METHODS

The tests used in laboratory evaluation of aggregates were:

Abrasion of Coarse Aggregates by Use of the Los Angeles Machine (Test Method Tex-410-A).

Ball Mill Method for Determination of the Disintegration of Flexible Base Material (Test Method Tex-116-E).

Modified Soundness of Aggregate by Use of Magnesium Sulfate (Test Method Tex-411-A).

IV. PROCEDURE

Four core drill samples were taken at random locations from I-10 roadway after injection of red liquid dye into surface cracks.

Visual inspection determined the condition of aggregate and depth of cracks.

Asphalt was extracted from the hot mix and a screen analysis made of aggregates.

Soil constants were determined and screen analysis made on base material from 2 of the core holes. (See Appendix)

Samples of aggregate from sixteen local pits throughout the District were tested by the Los Angeles Abrasion machine, Wet Ball Mill test and Soundness of Aggregate (Magnesium Sulfate) test. The latter test was modified to give more definitive results. (See Appendix for modified test).

VII. DISCUSSION

Core Hole Number 1 at Station 1206+25, 7 feet left of centerline.

A red liquid dye was injected into a surface crack for a distance of 14 inches along the crack until it was evident full penetration had occurred. The hot mix was then cored and a six-inch diameter core removed. The core separated at the plane of the hot mix and the two-course surface treatment. Moisture and dye were noted in this plane and the crack extended through the hot mix to the penetration surface. No dye or moisture penetrated the two-course surface treatment.

Approximately 1-1/2 inches of flexible base was stuck to the bottom of the two-course surface treatment and showed a well graded coarse aggregate distribution. The total depth of hot mix was 3-3/8 inches.

Core Hole Number 2 at Station 1215+75, 9 feet right of centerline.

The same procedure for dye injection and coring was used as with Core Hole Number 1. The core separated 2-1/2 inches below the surface at the plane between the two courses of Type "C" hot mix. Moisture and dye were noted in this plane, but no moisture or dye penetrated the bottom course to Type "C" hot mix or the two-course surface treatment. After a more thorough inspection of the bottom course of Type "C" hot mix, a small hairline crack was noted to a depth of 3/4 inch. This hairline crack did not completely penetrate through the bottom course of Type "C" hot mix. There was no cracking of the two-course surface treatment.

Core Hole Number 3 at Station 1215+95, 1 foot right of centerline.

Dye was not used as the hole was cored to check on moisture accumulation in the crack from showers the day before. Even though the crack was quite large, moisture accumulation could not be detected. There was no separation of the different courses of hot mix or between the hot mix and two-course surface treatment. The crack did penetrate all courses of hot mix but did not penetrate the two-course surface treatment.

Core Hole Number 4 at Station 1216+00, 1 foot right of centerline.

The same procedure for dye injection and coring was used as with Core Hole Number 1. The crack was the same crack as that for Core Hole Number 3. The core separated 2-3/8" below the surface at the plane between the two courses of Type "C" hot mix. Dye and moisture were noted in this plane. The moisture and dye penetrated the bottom course of Type "C" hot mix, the two-course surface treatment and to a depth of approximately 1-1/4 inches in the flexible base. The dye penetration of the flexible base was along the crack but at the center one-third of the hole.

Initial visual inspection of the surface indicated shelling of the aggregate, but upon close examination it was found that the aggregate at the surface had dissolved under weathering conditions and traffic.

As the liquid dye was being injected into the cracks, it was noted that numerous uncoated aggregate in the hot mix disintegrated and dissolved as the liquid soaked into them.

From a discussion with the Maintenance Foreman it was learned that the surface cracks in the immediate area of Station 1216+00 were the first to appear in the roadway. It was also revealed that cracking increased rapidly after a snow and ice storm in the early fall of 1968. The Maintenance Foreman also stated that no cracking had occurred in the two-course surface treatment prior to the placement of hot mix asphaltic concrete.

Flexible Base samples were taken from core holes numbered 1 and 2.

The depth of the surface cracking was generally limited to the depth of the hot mix and only occasionally penetrated through the two-course surface treatment into the base. Investigation of the other fifteen projects confirmed the depth of surface cracking.

Cracking originated at the surface and continued downward.

Severe weather conditions and sudden changes in temperature rapidly increased the rate of cracking and deterioration of the surface.

Cracking appeared to be more heavily concentrated in the western (Control: 441 - Section: 6) area. A check of the job control records indicated approximately 0.3% less asphalt was used in the western (Control: 441 - Section: 6) area than in the eastern (Control: 441 - Section: 7) area. Asphalt content of the hot mix was limited by Special Provision 340-046 in requiring 96% ($\pm$ 1.0%) laboratory density.

It was considered during the production of the hot mix aggregates that the aggregate was of doubtful quality although the material did meet all specification requirements, including the Los Angeles Abrasion Test (Test Method Tex-410-A).

There was considerable oxidation of the asphalt, absorption of asphalt into the softer aggregates, and loss of volatiles noted during the preparation of the hot mix for extraction tests.

A review of the Los Angeles Abrasion values for all sources was made to determine the possibility of lowering the required value. Results from the various sources showed no set pattern or conclusive difference among aggregates (see Appendix).

Results obtained from the Wet Ball Mill test on the sixteen aggregates were inconclusive.

After consideration of ASTM C 88 soundness test, it was decided to use a modified method. The magnesium sulfate method was used because the solution was easier to hold in suspension and gave a wider range of results. Because the coarse aggregate in the Type "D" hot mix and the intermediate aggregate in the Type "C" hot mix contained both coarse and fine aggregate according to ASTM test procedure, it was decided that the test should be modified to include all sizes of aggregate from each coarse aggregate stockpile. These would be taken as produced and all sizes would be considered as 100% without differentiation between coarse and fine. In this manner material would be tested as actually used in the hot mix.

After further review and evaluation of the soundness test results and roadway deterioration, a maximum value of 25 percent unsound material after four cycles of the modified magnesium sulfate test was adopted based upon those roadways which were considered to be servicable and unservicable. The revised soundness test is included in the Appendix.

APPENDIX

SOUNDNESS OF AGGREGATE FOR USE IN

BITUMINOUS MIXTURES AND SURFACE TREATMENTS

Scope:

This test method covers the procedure to be followed in testing aggregates to determine their resistance to disintegration by a saturated solution of magnesium sulfate. The test as performed is a modification of ASTM designation C-88 and the results are determined after 4 cycles of the aggregate in a saturated solution of magnesium sulfate. For this test, all stockpiles consisting of 85% or more + 10 material shall be considered coarse aggregate stockpiles. Apparatus and Special Solutions Required are as specified in ASTM Designation C-88.

Preparation of Sample:

(A) Obtain a representative sample of aggregate from each coarse aggregate stockpile. The sample shall be of such size that it will yield not less than the following amounts of the different sizes, which shall be available in amounts of 5 percent or more.

Size (Square Opening Sieves)	
3/4 to 3/8 in.	1000 grams
3/8 to No. 4	300 grams
No. 4 to No. 8	100 grams
No. 8 to No. 16	100 grams
No. 16 to No. 30	100 grams
No. 30 to No. 50	100 grams

(B) Should the sample contain less than 5 percent of any of the sizes specified in the paragraph above, that size shall not be tested, but for the purpose of calculating the test results, it shall be considered to have the same loss in magnesium sulfate treatment as the next larger or the next smaller size. The material passing the No. 50 sieve shall be assumed to have 0 percent loss.

(C) Thoroughly wash the sample of aggregate, dry to a constant weight at 200° - 230° F, and separate into the different sizes shown in paragraph (A) by sieving to refusal. Do not use aggregate sticking in the meshes of the sieves in preparing the sample. Weigh out the proper weight for each individual size and place in separate containers for the test.

Procedure:

(A) Storage of samples in solution. Immerse the samples in the prepared solution of magnesium sulfate for not less than 16 hours nor more than 18 hours in such a manner that the solution covers them to a depth of at least 1/2 inch.

(B) Drying samples after immersion. After the immersion period, remove the aggregate sample from the solution and permit it to drain for 15 ± 5 minutes. For pans containing finer particles of aggregate, solution should be drained through a finer meshed sieve than the aggregate particle. Place samples in oven and dry to constant weight at 200° - 230° F, not less than 4 hours. After constant weight has been achieved, allow the samples to cool to room temperature, when they may again be immersed in the prepared solution as described in Paragraph (A).

(C) Number of Cycles. Repeat the process of alternate immersion and drying until four cycles have been completed.

Quantitative Examination:

(A) After the completion of the final cycle and after the sample has cooled, wash each individual size of aggregate free from the magnesium sulfate as determined by the reaction of the wash water with barium chloride ($Ba\ Cl_2$).

(B) After the magnesium sulfate has been removed, dry each individual size of aggregate to a constant weight at 200° - 230° F, and sieve the aggregate over the sieve shown below for the appropriate size of particle.

Size of Aggregate	Sieve used to Determine Loss
3/4 to 3/8 in.	5/16 in.
3/8 to No. 4	No. 5
No. 4 to No. 8	No. 8
No. 8 to No. 16	No. 16
No. 16 to No. 30	No. 30
No. 30 to No. 50	No. 50

Reporting:

The following should be included when reporting test results:

(A) Weight of each fraction of each sample before test.

(B) Material from each fraction of the sample after final sieving, on which the fraction was retained before the test, expressed as a percentage by weight of the fraction.

(C) Weighted average calculated from the percentage of loss for each fraction, based on grading of the total sample as received for testing. (See Table)

Passing	Retained	Grading of original Sample %	Weight of Test Fractions Before Test (Grams)	Percent Loss of Test Fractions After Test	Weighted Average Correct % Loss
3/4 inch	3/8 inch	16.3	1000 grams	20.2	3.3
3/8 inch	No. 4	72.5	300 grams	25.0	18.1
No. 4	No. 8	7.8	100 grams	26.7	2.1
No. 8	No. 16	2.1	---	26.7 (A)	0.6
No. 16	No. 30	1.0	---	26.7	0.3
No. 30	No. 50	0.3	---	26.7	0.1
Totals		100.0	1400 grams		24.5

Note:

(A) The percentage loss of the next larger size is used as the percentage loss for this size, since this size contains less than 5 percent of the original sample.

(B) In these calculations sizes finer than the No. 50 sieve shall be assumed to have 0 percent loss.

SOUNDNESS TEST $Mg\ SO_4$ (MODIFIED)

Hot Mix Type C Aggregate	Fine Graded			Average Graded			Coarse Graded		
Source	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle
Willbanks Pit	56.00	69.88	77.13	58.80	70.43	77.20	59.99	70.98	77.27
Jeff Davis Pit	24.30	44.08	51.50	24.12	42.88	52.72	24.85	43.10	53.69
Moss Pit	22.84	39.60	44.18	20.09	38.33	39.96	18.97	37.90	38.27
Hoard Pit	17.50	27.75	42.75	15.50	24.71	40.20	14.74	23.81	39.41
Cox Adams Quarry	7.89	19.02	34.10	6.66	16.92	31.70	6.24	16.31	31.21
(Spur, Ward County) University Pit	15.84	24.51	29.61	13.37	22.09	27.39	12.28	21.17	26.69
Avery Pit (Ward Co.)	6.16	14.26	21.81	4.68	13.94	18.02	4.23	13.68	16.71
Jones Pit N. of I-20	7.92	18.94	29.52	8.14	18.74	29.16	8.45	18.89	29.25
Jones Rochester Pit	3.54	9.45	16.42	2.80	7.06	13.43	2.70	6.36	12.68
Clayton Williams Pit	6.43	13.09	19.22	3.98	8.84	12.77	3.33	7.42	10.35
Strain Pit (St. 18)	2.02	7.70	15.86	1.37	5.93	12.38	1.13	5.52	11.46
Graves Pit (Strain)	11.21	15.71	16.45	10.86	15.42	15.47	10.74	15.36	15.17
Hoban Pit	0.85	1.71	3.13	0.21	0.68	1.55	0.07	0.44	1.17
Border Rd. (Davis Mt)	1.01	2.76	5.07	0.32	1.18	3.15	0.11	0.63	2.41
Martin (Addis) Pit	6.86	19.94	31.22	6.47	19.51	30.57	6.37	19.59	30.60
Counts Pit	8.74	18.04	31.04	7.09	15.30	28.06	6.59	14.45	27.14

SOUNDNESS TEST Mg SO_4 (MODIFIED)

Hot Mix Type D Aggregate	Fine Graded			Average Graded			Coarse Graded		
Source	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle	% Unsound 2nd Cycle	% Unsound 3rd Cycle	% Unsound 4th Cycle
Willbanks Pit	53.83	70.99	77.25	52.98	70.27	77.16	53.43	69.27	77.03
Jeff Davis Pit	27.13	49.40	52.60	25.12	47.68	51.59	22.68	44.27	50.23
Moss Pit	26.21	41.61	49.57	25.96	41.30	59.09	25.36	40.74	48.03
Hoard Pit	20.36	33.38	47.33	20.00	32.28	46.47	19.32	30.44	45.01
Cox Adams Quarry	9.80	22.94	39.79	9.51	22.16	38.38	9.00	20.87	36.16
(Spur, Ward County University Pit	18.59	27.93	33.49	18.48	27.52	32.77	18.15	26.72	31.57
Avery Pit (Ward Co.)	8.96	15.72	28.07	8.45	15.30	27.19	7.65	14.67	25.83
Jones Pit N of I-20	8.76	20.38	31.17	8.23	19.80	30.57	7.39	18.88	29.62
Jones Rochester Pit	5.58	13.97	22.75	5.02	13.06	21.31	4.16	11.57	19.00
Clayton Williams Pit	11.44	20.09	28.44	10.35	18.92	27.28	8.58	16.90	25.09
Strain Pit (St. 18)	2.99	11.65	22.94	2.86	10.71	21.40	2.61	9.23	18.91
Groves Pit (Strain)	11.42	16.23	18.03	11.33	16.02	17.67	11.24	15.76	17.12
Hoban Pit	2.29	3.94	6.61	1.95	3.41	5.80	1.40	2.59	4.51
Border Rd. (Davis Mt.)	1.89	4.13	5.51	1.63	3.64	4.94	1.22	2.87	3.99
Martin (Addis) Pit	7.64	21.85	33.70	7.46	21.21	32.91	7.17	20.26	31.73
Counts Pit	11.68	22.93	36.35	11.11	22.01	35.36	10.18	20.47	33.68

Abrasion Test for Hot Mix Aggregates

ITS		ABRASION
illbanks		28.4 (C)
eff Davis		36.2 (C) 34.6 (B)
oss		35.0 (B)
oard		27.2 (C) 30.2 (C)
ox Adams		36.6 (C) 39.4 (D)
niversity Pit		29.8 (C)
very Pit		28.2 (C)
ones Pit	29.1 (C)	29.2 26.5
ones Rochester		36.4 (C) 30.5 (C)
layton Williams		31.4 (C)
train (St. 1S)		32.4 (C)
oban		18.7 (B)
roves Pit (Strain)		17.5 (B) 24.3 (B)
order Road (I-20-1(46)21)		26.1 (C)
rtin (Addis)		31.8 (C)
ounts		29.5 (C)

(MODIFIED) 4 Cycle $MgSO_4$ SOUNDNESS TEST & L. A. ABRASION OF AGGREGATES

Road	County	Control	Section	Project	Pit	Date Completed	Percent Unsound Ty C	Ty D	Los Angles Abrasion
I-20	Martin	5	4	I-20-1(61)22 etc.	Jeff Davis	Fall 1968	52.7	51.6	36.2 - C
I-20	Midland	5	15	I-20-1(9)144	Cox-Adams	Fall 1968	31.7	38.4	36.6 - C
I-20	Midland	5	14	I-20-1(15)120	Hoard	Fall 1968	40.2	46.5	30.2 - C
I-20	Ector	4 & 5	7 & 13	I-20-1(17)111	Moss	Winter 68-69	39.9	49.1	35.0 - B
I-20	Ward	4	4	I-20-1(12)062	Univ. Pit	Winter 66-67	27.4	32.8	29.8 - C
I-20	Ward	4	2	I-20-1(11)046 etc.	Avery Pit	Winter 69-70	18.2	27.2	28.2 - C
I-20	Reeves	3	7	I-20-1(64)036	Groves Pit	Winter 68-69	15.5	17.7	24.3 - B
I-20	Reeves	3	6	I-20-1(21)026	Hoban Quarry	Winter 69-70	1.6	5.8	18.7 - B
I-10 I-20	Jeff Davis Reeves	3	4 etc.	I-10-1(86) etc.	(TXL) Border Road	Fall 1969	3.2	4.9	26.1 - C
I-10	Reeves/Pecos	441	7 etc.	I-10-2(21)222 etc.	Wilbanks Pit	Fall 1966	77.2	77.2	28.4 - C
US 80	Midland	5	2	C 5-2-48 etc.	Counts	Fall 1970	28.1	35.4	29.5 - C
US 385	Ector	229	1	C 229-1-12 etc.	Martin Addis	Summer 1970	30.6	32.9	31.8 - C
US 80	Ector	5	1	F 235(32)41	Jones Bros.	Winter 67-68	29.2	30.6	29.1 - C
US 385	Crane	229	3	C 229-3-20	Jones Rochester	Summer 1969	13.4	21.3	36.4 - C
US 285	Pecos	139	8	C 139-8-16	Clayton Williams	Summer 1969	12.8	27.3	31.4 - C
ST. 18	Pecos	292	6 etc.	C 292-6-13	Strain Bros.	Summer 1969	12.4	21.4	32.4 - C
I-20	Reeves	3	5	I-20-1(81)001	Border Rd. TXL	Winter 71-72	2.2	9.9	27.6 - C
I-20	Ector	4	7	I-20-1(83)104	Rodman	Winter 72-73	18.7	31.8	25.7 - C
I-20	Ector	4	7	I-20-1(83)104	Barber O'Daniel	Winter 72-73	5.7	7.4	21.8 - C

Texas Highway Department
Form 476A

SOILS AND BASE MATERIALS TEST REPORT

Laboratory No. 69-75-76
Date Rec'd 1/17/69 Reported 1/24/69
Engineer Merlin O. Bennett
Address Pecos, Texas
Contractor Investigation
Sampler Don Bradley
Sampler's Title Engr. Tech V
Sampled From Roadway
Producer Investigation
Quantity Represented by Sample Ample
Has been Used on No

Control Number	Section Number	Job Number
441	6	

County	Federal Project No.	Highway No.
Reeves		IH-10

District No.	I.P.E. No.	Req. No.	Date Sampled
6	3-200		1/17/69

Specification Item No.
Material from Property of

Proposed for Use as Investigation

Lab. No.	LL	PI	SL	LS	SR	Class	Soil Binder	WBM % Loss	% Moist.	Depth
* 69-75	24.8	9.3	15.8	5.5	1.89	A-2-4	37.7	44.9		Full Depth
* 69-76	25.3	7.9	17.2	4.6	1.95	A-2-4	38.8	47.9		Full Depth

PERCENT RETAINED ON

Lab No.	Square Mesh Sieve															Grain Diam. in Millimeters			Specific Gravity
	Opening in Inches								Sieve Numbers										
	3	2½	2	1¾	1¼	⅞	⅝	⅜	4	10	20	40	60	100	200	.05	.005	.001	
69-75				0	0	10	16	24	34	46	56	62							
69-76				0	0	11	15	24	32	46	56	61							

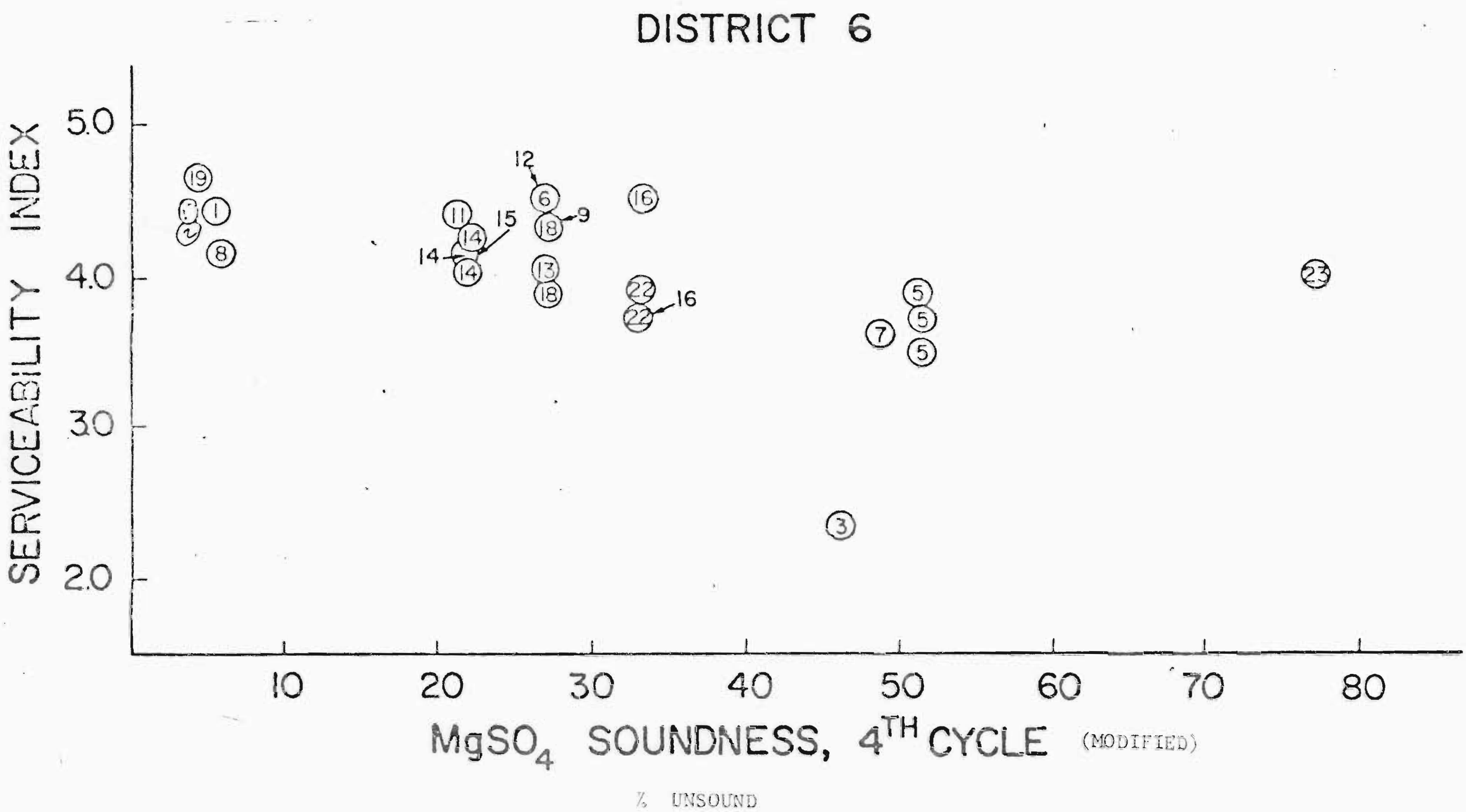
SAMPLE IDENTIFICATION

Lab. No.	Identification Marks	Location—Properties—Station Numbers	Type of Materials
69-75	Test Hole #1	Station 1206+25 7' Lt. ℄.	
69-76	Test Hole #2	Station 1215+75 Rt. ℄.	

* Samples include all flexible base courses

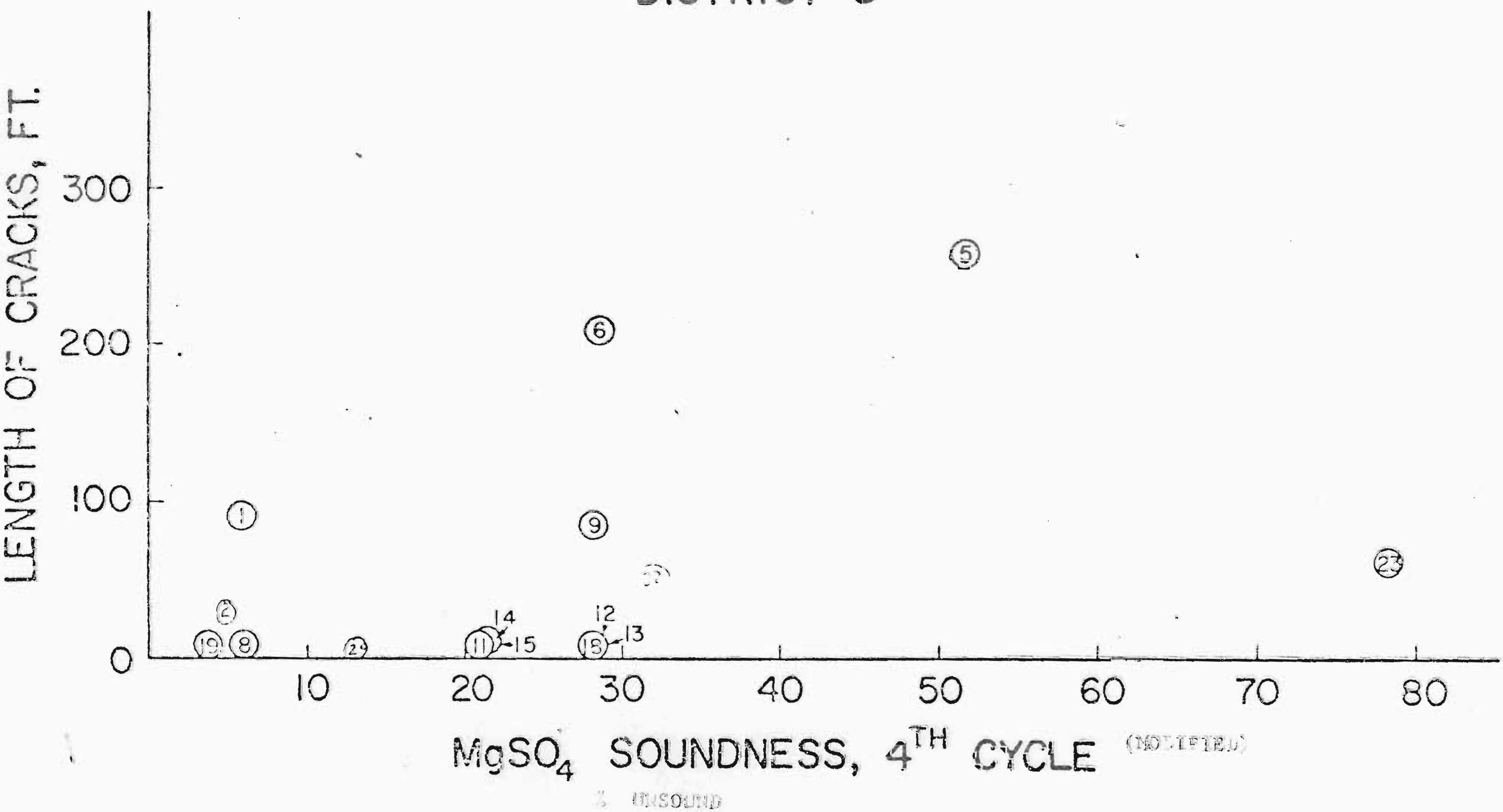
Dist. 6 Laboratory

SERVICEBILITY INDEX VERSUS % UNSOUND PARTICLES

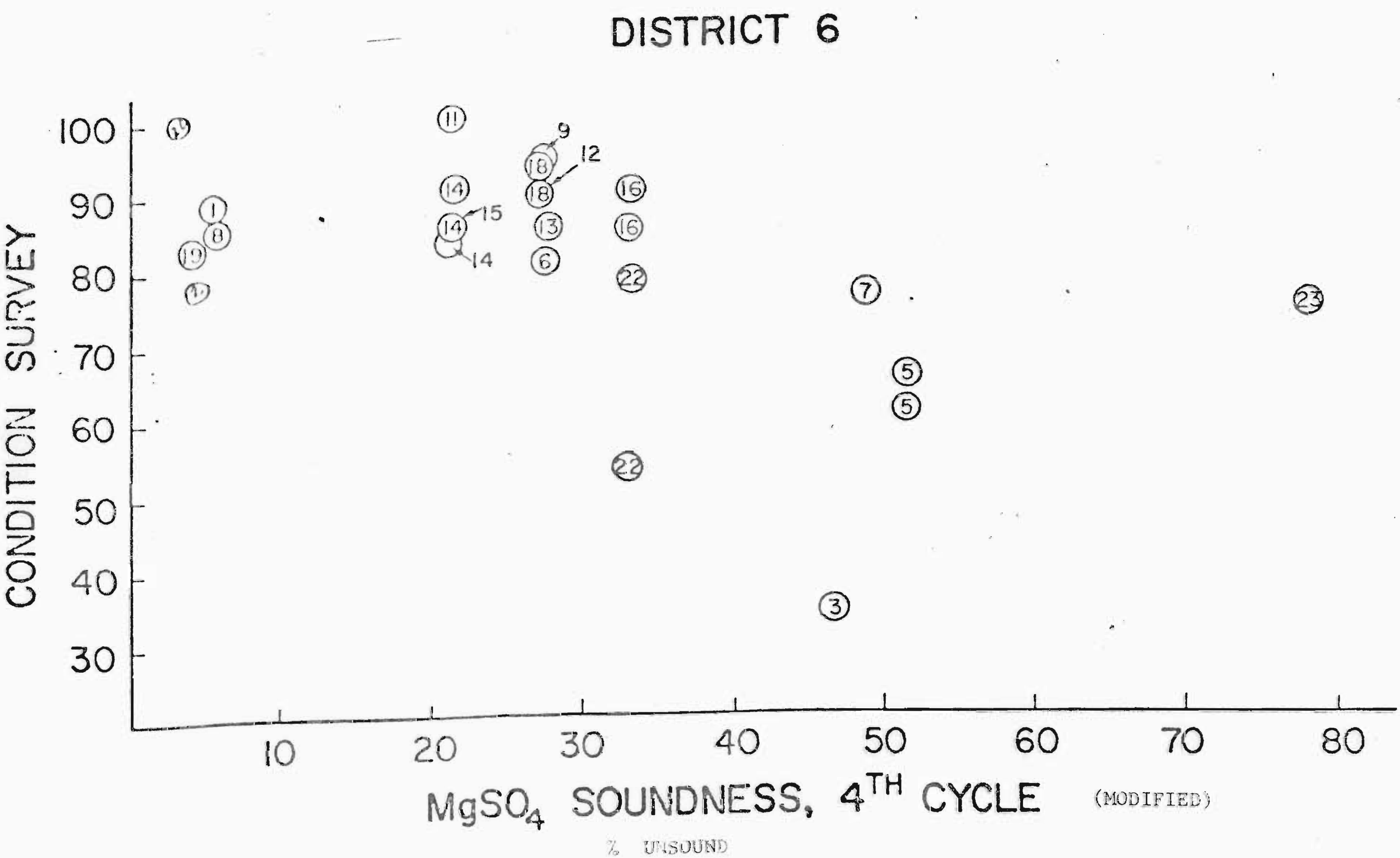


LENGTH OF CRACKS, FT. VERSUS % UNSOUND PARTICLES

DISTRICT 6



CONDITION SURVEY VERSUS % UNSOUND PARTICLES



Texas Highway Department

Materials and Tests Division

BALL MILL METHOD FOR DETERMINATION OF THE DISINTEGRATION OF FLEXIBLE BASE MATERIAL

Scope

This test method describes a procedure for determining the resistance of the aggregate in flexible base material to disintegration in the presence of water. The test provides a measure of the ability of the material to withstand degradation in the road base and detects soft aggregate which is subject to weathering. This test is known as the Texas Ball Mill value.

Apparatus

1. Texas Ball Mill: The mill shall conform in all its essential dimensions to the design shown in Figure 1. The machine consists of a watertight steel cylinder, closed at one end, having inside dimensions of 10-3/16 inches diameter and 10-3/4 inches in length. The cylinder is fitted with a removable lid with watertight gasket attached. The cylinder is mounted in a rigid support in such a manner that it is rotated about the central axis in a horizontal position. A steel baffle, projecting radially 3-1/4 inches into the cylinder and 10-3/4 inches in length, is welded along one element of the interior surface of the cylinder. The baffle shall be of such thickness and so mounted as to be rigid. The machine should be operated at a uniform speed of approximately 60 r.p.m.

2. Metallic Spheres: The abrasive charge consists of 6 steel spheres approximately 1-7/8 inches in diameter, weighing between .9 lb. and 1.0 lb. each. (409 and 454 gms.)

3. Toledo Scales, or equivalent, of 30 lbs. capacity sensitive to .01 lbs. or less.

4. Sieves, No. 40 mesh and 1-3/4 inch

5. Oven, an air-dryer with temperature range of 120°F to 140°F.

6. Crusher

7. Miscellaneous equipment includes large pans, wash bottles, etc.

Test Record Form

Each sample shall be given an identification number and a card bearing the number should be placed with each portion of the sample throughout the processing and testing of the material. Record the test data on Work Card, Form 359.

Procedure

1. Secure a representative sample of the total material of sufficient size to yield more than the quantity required, in paragraph 4, (7 3/4 lbs.) of air dry material. Sixteen to eighteen pounds is a convenient size.

2. Crush oversize particles to pass a 1-3/4 inch sieve

3. Air dry the sample at a temperature not to exceed 140°F.

4. Reduce air dry sample of total material by sample splitter, or quartering methods to approximately 7 3/4 pounds. Adjust weight to 7 3/4 pounds plus or minus 0.1 pound of air dried sample. Place sample in pan and cover with water for 1 hour. (One-half gallon is usually sufficient.)

Note:

a. When testing borderline materials for compliance with specifications or running referee tests requiring accurate determinations, the minus No. 40 portion of the Wet Ball Mill Test should be in conformity with the amount of minus No. 40 material in the screen analysis sample. A check of the minus No. 40 in the sample can be done by screening the air dry material over the No. 40 sieve. When the Wet Ball Mill Test fines have been adjusted properly then recombine the sample and continue.

b. Air dry materials prepared for triaxial test (Test Method Tex-101-E, Part II) may be weighed accumulatively from the prepared separated sample.

5. Decant all free water from sample into a 1/2 gallon container, finish filling container with clear water and use to wash sample into ball mill.

6. Place the 6 steel spheres in the ball mill, fasten the watertight lid securely and rotate 600 revolutions at the rate of approximately 60 r.p.m.

7. When the 600 revolutions are completed, remove the cover and carefully empty the cylinder contents into a pan.

8. Remove the steel spheres and separate the sample by washing over the No. 40 sieve.

9. Dry the aggregate portion retained on sieve to constant weight at 140°F rescreen over the No. 40 sieve and weigh.

Calculations

Calculate the percentage of soil binder from the Texas Ball Mill test as follows:

$$\text{Texas Ball Mill Value} = \frac{A - B}{A} \times 100$$

Where: A = dry weight of total sample (step 4)

B = weight of retained material (step 9)

Precautions

1. Always use dry material in performing test.
2. Avoid the loss of portions of sample in transferring into or out of cylinder.
3. Use only 1/2 gallon of water in cylinder with wet sample from which free water has been decanted.
4. Check weight of steel spheres periodically for loss due to wear.

Charts

Figure 2 and Table I show typical test data.

Reporting Test Results

Report the Texas Ball Mill value on Form 476-A.

Notes

This procedure is not a substitute for Test Method Tex-101-E and should not be used generally for the preparation of soil samples for determination of standard soil constants and hydrometer analysis. The test furnishes valuable supplementary data pertaining to the quality of the aggregate portion of flexible base material. The Texas Ball Mill test is more reliable than the Los Angeles abrasion test in evaluating the quality of base materials.

TABLE I

	Percent Soil Binder			
Lab. No.	Standard Soil Test	Texas Ball Mill Value	Los Angeles Wear Test	Type of Material
41-83-R	5	10	28	Hall Bros. Cr. Limestone
42-425-E	1	6	28	Chico Cr. Limestone
42-426-E	1	6	16	Trap Rock
42-427-E	6	17	30	Servtex Cr. Limestone
41-49-R	9	70	55	Austin Chalk (poor quality)
42-354-E	17	36	78	Cr. Limestone (good quality)
41-125-E	4	22	40	Cr. Limestone (good quality)

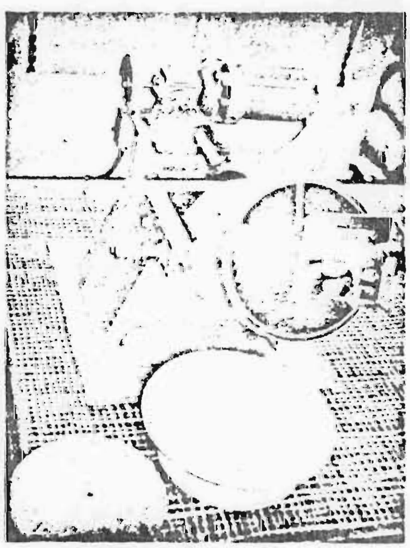


Figure 1a
Wet Ball Mill Showing Baffle and Charge

Figure 1b
Wet Ball Mill - Cantilevered Type

RELATION BETWEEN PERCENT SOIL BINDER FROM TEXAS BALL MACHINE AND PERCENT SOIL BINDERS BEFORE AND AFTER ROLLING

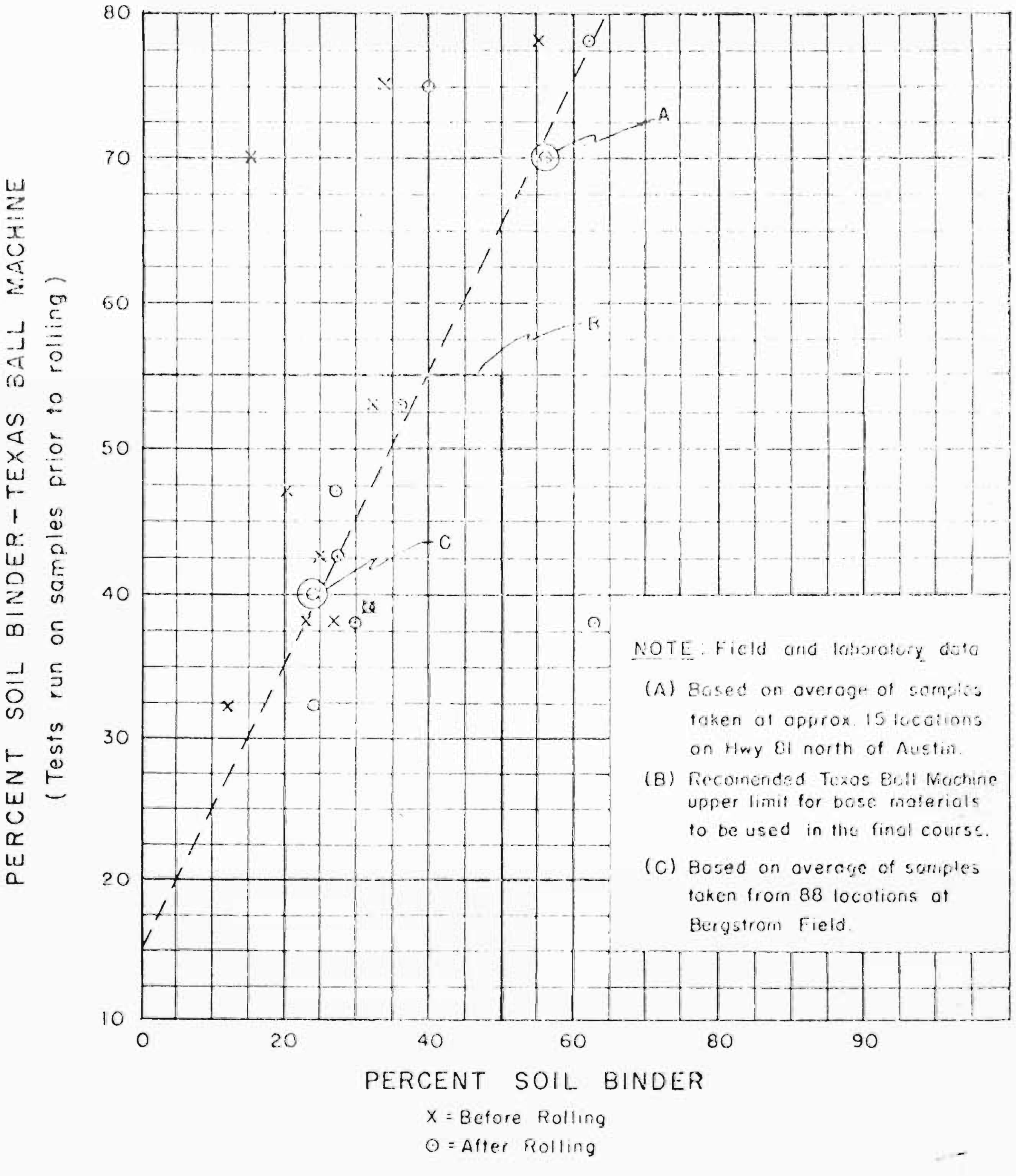


Figure 2

Texas Highway Department

Materials and Tests Division

ABRASION OF COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE

Scope

This Test Method covers the procedure for testing conventional and lightweight coarse aggregate for resistance to abrasion in the Los Angeles testing machine with an abrasive charge. The apparatus and procedure used in this test are identical with A.S.T.M. Designation: C 131.

Procedure

Use the apparatus specified to prepare and the required gradings of aggregate in accordance the procedure described in A.S.T.M. Designal C 131.

Reporting Test Results

Report the test data and type grading and wear to the nearest whole percent on Form No. 272

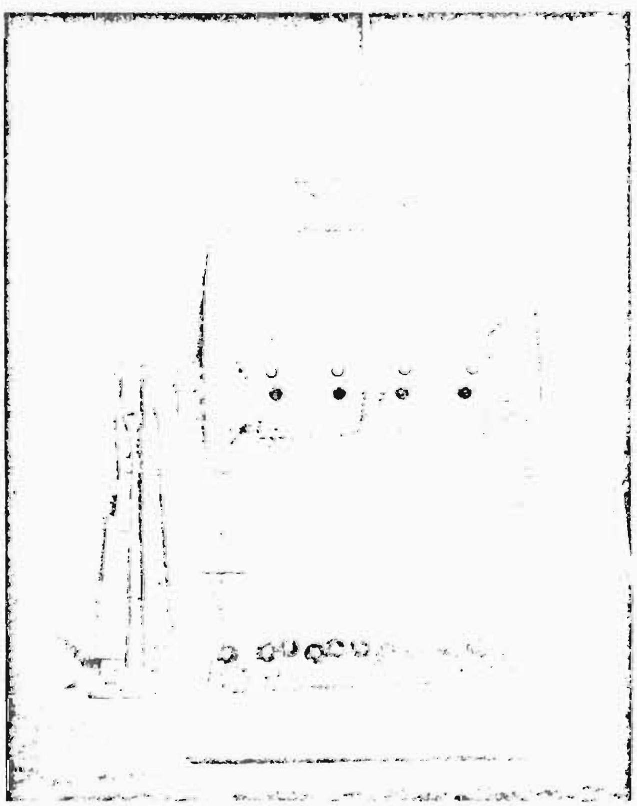


Figure 1

Texas Highway Department

Materials and Tests Division

SOUNDNESS OF AGGREGATE BY USE OF SODIUM SULPHATE OR MAGNESIUM SULPHATE

Scope

This test method covers the procedure to be followed in testing aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulphate or sodium sulphate. Attention is called to the fact that test results by the use of the two salts differ considerably and care must be exercised in fixing proper limits in any specification which may include requirements for these tests. The test as performed is identical with A. S. T. M. Designation: C 88 and the results are determined after 5 cycles of the aggregate in a saturated solution of magnesium sulphate or sodium sulphate.

Procedure

Use the apparatus to prepare and test samples of aggregate as specified in A. S. T. M. Designation: C 88. Prepare the saturated magnesium sulphate or sodium sulphate solution several days prior to testing to regulate the temperature and specific gravity of the solution. Determine the percent loss of aggregate after 5 complete cycles of wetting in solution and drying.

Reporting Test Results

Report the weighted average percent loss calculated on the basis of the total sample on Form No. 272.

Notes

1. Check both the temperature and the specific gravity of the solution daily as test reproducibility will be affected if these factors are allowed to vary from the test requirements.

2. The aggregate must be completely dried and then cooled to room temperature to prevent any disintegration which may be caused by sudden temperature changes in the aggregate.